The Making of

ROCKETS.

In Two Parts.

The First

Containing the Making of Rockets
for the meaneſt Capacity.

The other

To make Rockets by a Duplicate
Propoſition, to 1000 pound
Weight or higher.

*Experimentally and Mathematically
Demonſtrated, By*

ROBERT ANDERSON.

L O N D O N:

Printed for *Robert Morden,* at the *Atlas* in
Cornbil. 1696.

To the Right Honourable

HENRY

Earl of *Romney*.

Vicount Sidney *of* Sheppy, *Baron of* Milton, *Mafter General of his Majefty's Ordnance, Conftable of* Dover *Caftle, Lord Warden of the* Cinque *Ports, and one of the Lords of his Majefty's moft Honourable* Privy Council.

WELL knowing my moft Noble Lord, that thefe things will eafily receive Perfection in your Hands, which for many Reafons are beyond my reach.

This Treatife (if it may deferve that name) is the leaft in

Bulk, and ſeemingly relating to the ſleighteſt Subject I have met withal in *Pyrotechnia.* But in the many Volumns great and ſmall that I have read relating to theſe Matters in our own and other Languages; I do not find the leaſt Pretence or Thought of doing *that* which here is undertaken, *viz. To raiſe ſo great a heap of Fire, and to confirm the Fact by the greateſt Proofs that can be had or wiſh'd for, which are Experiments and Demon-ſtrations Mathematical.* Yet this a-lone is not the matter aim'd at, the Problem is univerſal, and ap-plicable to the Fortifications of all ſorts of Guns and other Engines with their Carriages, *&c.* and is *to increaſe or decreaſe the ſtrength of Materials according to the Effects and Services required.* But the great-eſt Skill in this Undertaking being

to adjuſt the Inſtrument and Means in a due and proper Proportion to the Effect ſought for; I do with all Humility and profound Re-ſpect make offer of this ſmall Eſ-ſay.

It is your Lordſhips great Abi-lities and Merit, that has enabled you to tread the intricate and pain-ful ſteps of Greatneſs; and by the well diſcharging ſo many E-minent Employments, to add, (if any thing can be added) to the Great Name of your Renown-ed Anceſtors. An ardent Zeal for the Welfare and Honour of your Country, has always been the inbred Vertue of your Family, and which is brought to its Per-fection in your ſelf.

The Name of *Maſter General* of the *Ordnance,* lays Claim to all my (more than 25 Years) Ex-

perience and Studies about the Art of Shooting in all ſorts of Great Artillery amounts to : But the adding ſomething (according to my poor Sphere and Capacity) to the Defence, Safety and Reputation of my Native Country, has at all times ſo intirely govern'd me, that upon this account alſo, and indeed chiefly, I am emboldned to lay this mean Attempt of mine before your Lordſhip; truſting that it may at ſome time or other undergo a Trial, and by your Lordſhips Favour receive a meet Incouragement, and procure your Lordſhips Pardon, *&c.* to

My Lord,

Your Lordſhips moſt Obedient,

Humble Servant,

Robert Anderſon.

TO THE
Young Pyrobolistes.

ROckets are the moſt *Artificial piece of Fire-work yet uſed amongſt the Pyroboliſtes, and hath been more uſed of late Years than formerly, and that the Young Artiſts may not ſpend their Time and Money unneceſſarily, I have given eaſie, plain, and ready Rules for making of Rockets to two Inches and half Diameter, which is ſufficient for all private Occaſion, viz. Of the Mould of a Rocket. Of the Rouler and Caſe. Of the Compoſitions. Of the Receipts of Rockets. Of the Driver. Of the Boring of the Rocket. Of the Stars and other Matter to be put in the Head of a Rocket. To Head a Rocket. Of the Sticking of a Rocket. And laſtly, to Fire the Rocket. And ſome Obſervations about the manage-*

ment

ment of a Rocket in general ; all which I hope will prove easie and beneficial to the Ingenious, and those that are willing to Learn : and what you do, endeavour to do it well, and do not be Conceited; which if so, I have my ends. And from these little beginnings greater Matters may be obtained, and you may become serviceable to your Country; in which be sure to be Careful, Honest and Faithful.

TO

TO THE

Other Pyrobolistes.

About fifteen Years since I considered of a method to increase or decrease the strength of the Metal of Guns, which is this that I intend to discourse of. And at the Close of a small Treatise to hit a Mark published in the Year 1691. I proposed that Problem in Print ; since that time there has been more than Ordinary occasion for it, by Reason of the new Casting of the Mortar-pieces. About two Years since I put that Problem into a method, and made a Draught of the whole matter to increase or decrease the strength of the Metal of a Gun in any possible Proportion assigned. But when I saw the Mortarpieces brought from Sea broke, it was thought to be a good time to shew it, which

which was done, and the whole matter difcourfed of at large, but it fignified 00. But now I apply that Problem to the making of Rockets for the young Artift, as you fee in its proper place. And it is manifeft that the young Rocket-makers of this City are very Careful and Artificial in their Rockets of 8 d. 12 d. or 18 d. value, otherwife they may break and fo lofe their Labour and Difcredit themfelves. Seeing thefe Mathematical Rules are fo applicable to the greateft nicety of the Rifing of all fizes of Rockets; is it not more valuable to be applied to thofe Chargeable Inftruments of War, viz. Guns of all forts, with their Carriages, and all other their Furniture?

As to the Doctrine of fhooting by the increafe and decreafe of Powder, this way of making of Rockets proves it to be abfurd; for all Rocket makers to this time weaken the Compofition of their Rockets, as their Rockets are in greatnefs, or having greater quantities of Compofi-

Compofition; and that by chance, and without any Mathematical Demonftration.

And alfo by Experience, in Table June 1. 1691. and in the firft Column Experiment 4, againft that in Column 2 you will find 4 Ounces of Powder, and in Column 3, 3377. Again, in Column 1, againft Experiment 1 in Column 2, you find ½ an Ounce of Powder, and againft that in Column 3, you find 213; now becaufe the Requifite of Powder are as 8 to 1, therefore I multiply 213 by 8, and it makes 1704, much fhort of 3377, which indeed fhould have been equal to the faid 3377. that is the Ranges upon the plain of the Horizon are not as the Requifites of Powder which projected thofe Ranges; the like may be done in all the other Experiments. I have made hundreds of Experiments in feveral forts of Mortar-pieces, and am ready to make as many more, all which will manifeftly confute the Doctrine of fhooting by the increafe and decreafe of

of Powder, and have often invited the firſt promoter of that Doctrine to ſee his Invention confuted; and I do here invite all the Practitioners in that Science of ſhooting by the increaſe and decreaſe of Powder, to come and ſee their Doctrine confuted. I do hear aſſert it is impoſſible ever to bring that way of ſhooting to be ſo exact and ready for uſe, in all or any ſorts of Guns, as the common or uſual way is, by keeping the Requiſites of Powder conſtant, and elevating the Piece. In the Complicating of Rockets, whoſe Diameters are at any great diſtance; we make uſe of Experiments of ſhooting made upon another Occaſion, and thoſe Experiments ſerves ſufficiently well; but if we were to do them juſtly according to Art, there ſhould be two even Chaſed Guns of the ſame Proportion as the Rockets are of, that is the Diameter of the expoſed Rocket 2½ Inch multiplied by 6 is 15 Inches, and thoſe ſhould be the Diameter and Length of one of the Guns: 4 Inches the Diameter of the other Rocket, multiplied by 6 is 24 Inches, which 4 Inches for the

the Diameter, and 24 Inches for the length ſhould be the other Gun, or any two Guns in that Proportion. For the Requiſite of Powder take the Cube of 4, which is 64, as alſo the Cube of 2½, which is 15.625, divide the greater Cube Number by the leſſer, and the Quotient is 4, ſufficiently near; ſo the Requiſites of Powder of theſe two Pieces are as 4 to 1, then take any reaſonable Requiſite of Powder for the 4 Inch Gun, then take the fourth part of that Requiſite for the Requiſite of Powder for the leſſer Gun, diſcharge them both at one degree of Elevation, and note their Ranges. Their Bullets are to be of the ſame Metal, and of the ſame likeneſs, and both exactly fit. In a Mathematical ſence theſe Ranges ſhould be equal; but by Combination the greater quantity of Powder aggitates more upon the great Bullet, than the leſſer Requiſites doth aggitate upon the leſſer Bullet, and that cauſes thoſe differences, the like when two quantities of Powder aggitate upon one Bullet; it is Experience only that deter-

To the other Pyroboliftes.

determines the matter. Although ftrange things fometimes happens; yet this we will Affert, and endeavour to maintain that Mathematical Knowledg, join'd with faithful Experiments, will do greater matters than moft Men commonly conceive.

Rob. Anderfon.

Rocket

Rocket Moulds are made by Mr. Cuggley juft without Cripplegate.

Taper Bits for Rockets, are made by Mr. Goode juft within Cripplegate.

Rods for Rockets, are made by Mr. Stateham in Token-Houfe-Yard, Lothbury. All three right good Workmen.

PROPOSITION I.

Of a Rocket-Mould.

LEt E M R D D H L E be a Rocket-Mould, A B the Diameter of it, *viz.* one Inch and half; Z K 4 Diameters; that is 6 Inches the height to be filled with Compofition, B E half a Diameter an overplus, Z C the height of the boring 4 Inches and $\frac{1}{2}$, or $\frac{3}{4}$ of the height of the Mould, G F the Orifice one third of the Diameter of the Rocket half an Inch,
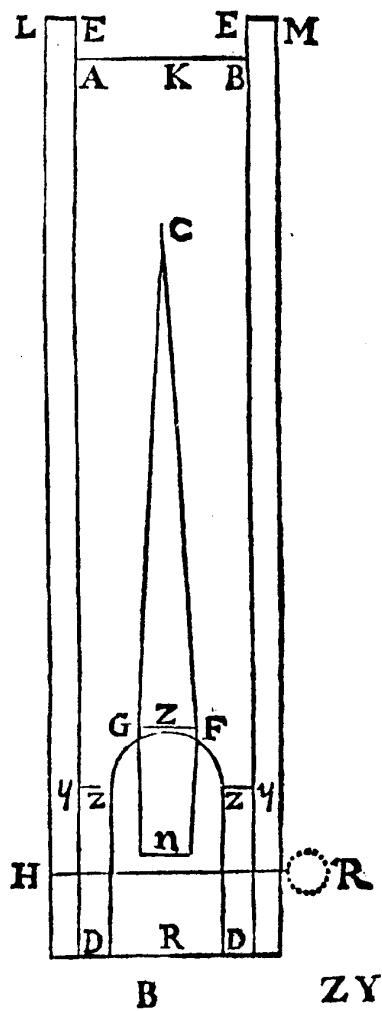
ZY one fixth of the Diameter of the Rocket a quarter of an Inch, the thicknefs of the Cafe, DYZGCFZYD the bottom of the Rocket-Mould with the Needle to be put in and taken out; RH a Pin of Iron to fix the Mould and Bottom together.

PROPOSITION. II.

Of the Rowler and Cafe of a Rocket.

MAke the Body of the Rowler nine Diameters in length, and in Diameter two thirds of the Diameter of the Rocket, and the Head of the Rowler of the Rocket the fame Diameter; let the Diameter of the Neck of the Rowler be a little lefs than one third of the Diameter of the Rocket, becaufe when opened with a Cone of Wood the Orifice of the Rocket may be juft one third fmooth and hard to endure the Fire. Then the thicknefs of the Cafe will be one fixth of the Diameter of the Rocket, which being well Rowled and Choaked, the Cafe may be finifhed.

(3.) Of

PROPOSITION III.

Of the Compofition for Rockets.

THE Ingredients which Rockets are Compofed of are Saltpetre, Sulphur, and Wood-Coal mealed, and paffed through a fine Sieve. Firft, take the largeft of Small-Coal made of Birch-Wood. Secondly, chufe the Yelloweft Roch Sulphur. Thirdly, take Saltpetre put in a Brafs Veffel, to which put fo much fair Water as will diffolve it, put that Veffel upon the Fire, when it boils fcum it clean; when the Water evaporates and confumes, ftir it with a Spatula of Wood to meal it, what remains of the Saltpetre upon the Spatula, and fides of the Veffel, rub off with your Spatula of Wood; then meal it, and pafs it through a fine Sieve. A fecond way to Clarifie Saltpetre; take a Crucible, fet it in the Fire, put Saltpetre thereunto, increafe the Fire till the Saltpetre be Reduced to a liquid quality like Water; when it boils take mealed Sulphur upon a Spatula of Iron, and put it into the boiling Saltpetre; fo often repeated, the Flegmy quality of

the

the Saltpetre will be burnt away, and the
flame will remain as white as the Body of
the Sun. Then pour it into some very
smooth Vessel, which being cooled, you
may reduce it into meal. These ways I
have done for my Recreation; but I usu-
ally take the cleanest Saltpetre to be found
in Drugsters Shops, and it does as well.

PROPOSITION IV.

The Receipts for Rockets.

FOR an Inch, an Inch and half, and
two Inch Rocket, and for a White
Fire, take 2 Drams of Antimony, 1
Ounce of Sulphur 2 ½ Ounces of Coal-
dust, 6 Ounces of Saltpetre, and 8 Ounces
of powder dust, [*Casimer du Grand Art d'
Artillerie, Partie* 1. *Livre* 3. *pag.*145.] Fill
4 Diameters and Bore 2 ½. For an Inch
and half, and two Inch, and two Inch
and half Rocket, and a Yellow Fire, take
1 Ounce of Sulphur, 1 Ounce of Coal-
dust, 4 Ounces of Saltpetre; or take 1 Ounce
of Sulphur, 1 ½ Ounce of Coal-dust, and
4 Ounces of Saltpetre. [*Casimer du Grand
Art d' Artillerie, Partie* 1. *Livre* 2. *pag.*99.]
Fill 4 Diameters, and bore 3, or a little
more

more. And *Daniel Elrich Der grossen
Kunst Artillerie Zweiter, Theil. pag.* 54.
*at.*19. Advises to take 1 Ounce of Sul-
phur, one Ounce of Coal dust, 4 Ounces
of Saltpetre. Again, take 1 Ounce of
Sulphur, 2 Ounces of Coal, and 6 Ounces
of Saltpetre; also take 1 Ounce of Sul-
phur 2 ½ of Coal, and 6 of Saltpetre.
*Johann. Sigmund. Buchner in Theoria &
praxis Artilleria Andere Theil, pag.*28. Weigh
the Ingredients single, put them into a
wooden Bowl, mix them very well toge-
ther, and pass them through the Sieve,
then your Composition is fit for use. In
filling Rockets of one or two Inches Dia-
meter; let them be filled at 6, 8, or 10
times Charging, and to every Charge 10,
12, or 14 blows with a Mallet, and be-
twixt every three blows turn the Dri-
ver a little in your Hand, so the Com-
position about the Needle will be pre-
served.

Some of our Rocket-Makers cry up
the Compositions of *Woolverman* and
Nelson, as though there was no Compo-
sition to be found like theirs, and they
are thus: that falsly called *Woolverman's*
is 1 of Sulphur, 1 of Coal, and 4 of
Saltpetre: and that of *Nelson*, 1 of Sul-
phur, 1 ½ of Coal, and 4 of Saltpetre,
as they stand in the Remains of

B 3   Mr. *Francis*

Mr. *Francis Deane*, fometime Gunner of the *Tower*. Thefe Compofitions are Old and Common, as you fee, they are Good, Strong, and dull Compofitions, and eafily mannaged. Thofe Compofitions where Powder is judicioufly mixed are more lively, and fo more difficult to mannage.

PRO-

PROPOSITION V.

Of the Driver of a Rocket.

LEt y A F G H E B y be the Driver of the Rocket, A F E B a piece of a Gun Barrel, F G H E O L a piece of Box or hard Wood, R L O q a hole for the Needle to pafs through, A C D B y a piece of Box to drive upon ; this we call a hollow Driver, it difpatches bufinefs quickly, and does right well. Or you may faften a piece of Brafs in the end of your Iron Driver with a hole in it to receive the Needle.

If any will ufe a folid Driver, let them have the bottom of the Mould as D y Z Z Z y D with a hole paffing through the bottom, as Z R, for a ftrait Piercer to pafs through
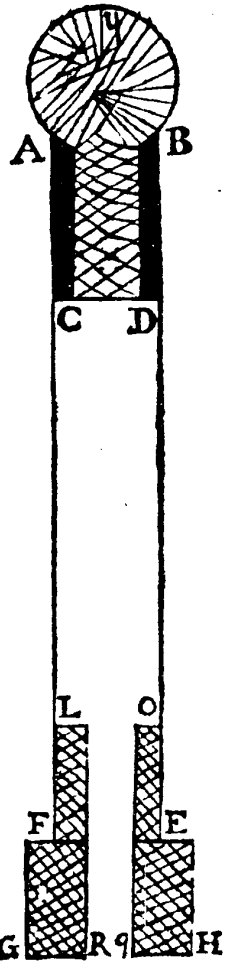
B 4

which

which bottom will be a Guide to the Piercer to be juſt in the middle of the Rocket, make a mark in your Piercer to be a guide to bore always an equal depth, then take your Rocket out of the Mould, open the hole with a Taper bit, and your Work is done, thus you may do for all ſizes of Rockets.

PROPOSITION VI.

Of the Boring of a Rocket.

MAke the Diameter of your Borer one third of the Diameter of your Rocket, not for any neceſſity, but for conformity to the other parts of the Rocket; from that Diameter let it be exactly Taper to a point. Further, there being an entrance made by the Needle, it is very eaſie to bore the Rocket very exactly, by holding the Rocket in the Left Hand, and the Borer in the Right, moving the Rocket in the Left Hand, keeping the Borer faſt in the Right Hand.

If you make the Diameter of the Needle one third of the Diameter of the Rocket, and ſo Taper, you need no Borer ;

Borer; here you ſhall find the Rocket will riſe ſwifter than when bored, the Compoſition lying looſer about the Needle than if it were bored, takes fire eaſier, and this is moſt neceſſary in large Rockets, *viz.* of 3, 4, or 6 Inches Diameter; for ſuch will hang too long time upon the Nails before they riſe. Thoſe Rockets whoſe Compoſitions are Compoſed of mealed Powder, Saltpetre, Coal and Sulphur, fill four Diameters, bore two and half. Thoſe Compoſed of Saltpetre, Coal, and Sulphur fill four Diameters, bore three or a little more.

This will hold in Rockets of 1 Inch, $1\frac{1}{2}$ and 2 Inches, but in larger Rockets there muſt be leſs ſolidity to the hollow Cone of Fire. I uſed for many years to drive my Rockets ſolid, and to bore them after, but that way did no better than theſe I now uſe and deliver ; but this is moſt certain that any one may drive and bore 3 Rockets with thoſe hollow Drivers which I now uſe, whilſt one many finiſh the driving and boring of one Rocket with a ſolid Driver; when the Rocket is near filled, uſe a ſhorter Driver with a ſmaller hole.

PRO-

PROPOSITION VII.

Of Stars for Rockets.

1, 1, 2, 2.   Sulphur.
2, 3, 3, 2.   Antimony.
4, 6, 8, 6.   Saltpetre.

Meal thefe Ingredients fine, pafs them through a Sieve, mix them with Water in which fome Glue, or Gum Araback, or Gum Dragon hath been diffolved, make them of the bignefs of a Hazle Nut, or fmall Wallnut ; roul them in meal Powder, when dryed they are fit for ufe.

Rockets are headed with fmall Serpents, their Orifices wafhed with mealed Powder and Brandy Wine, to take Fire.

Of

Of Rain and Hail.

TAke any of thofe Receipts for Stars, *viz.* 1 Sulphur, 2 Antimony, and 4 Saltpetre ; if you moiften that Compofition with Oil of Petre only made well into Pafte, formed into little Globes, rowled into mealed Powder ; fuch Stars will have Red Colour : the fame Compofition moiftned with Linfeed Oil will have a Red mixed with White : the fame Compofition mixed with Oil of Petre and Linfeed Oil mixed together, will make an Amethift Fire. All thefe will require a long time a drying, the beft time is to make them in the Summer.

The fame Compofition mixed with Gum Araback Water, and Colophone, gives a Red Yellowifh Fire. The former Compofition moiftned with Brandy and Oil of Petre, or Linfeed Oil, mixed together, requires lefs drying. Powder of Glafs, Powder made of Sawduft mixed with the former Compofition gives different Fire ; Coal duft inftead of Antimony, all which you may govern by your own Reafon. Take the Old Proverb, *So many Men, fo many Minds.*

(8.) *To*

PROPOSITION VIII.

To 'Head a Rocket.

TUrn a piece of Wood juſt ſo big as
your Rocket is, with a Cone at one
end thereof, paſte a piece of ſtrong Paper
about the Wood, then paſte another piece
of Paper about the Cone, and paſte both
Papers together; then put your Stars into
this Paper Veſſel, with ſome Rocket Com-
poſition to break the Veſſel, then put a
little Paſte a little within the ſides of this
Paper Veſſel, then draw it upon your
Rocket, and paſte it to the Rocket, ſo
your Work is done.

PROPOSITION IX.

Of the Sticking of Rockets.

THE Stick of a Rocket ought to be
ſeven times the length of the Rocket
or more, *viz.* a Rocket of an Inch
and half, ſix Diameters thereof, the length
of the Rocket, is nine Inches, ſeven
times

times nine is ſixty three Inches, that is
five Foot three Inches. The breadth of
the Stick at the Head, three quarters of an
Inch or leſs, the thickneſs half an Inch
or leſs, the ſmall end of the Stick three
eighths of an Inch and ſquare, and to be
made of light Deal; ſuch a Stick will do
very well, and may be counted Cuſtom
without Demonſtration. In the Winter
1695. there were two ſets of Fire-works,
in the firſt of which the Wind was North-
ward, and the Rockets in their riſing
worked into the Wind. In the ſecond the
Wind was Weſtward, and had the ſame
effect as the firſt; the Reaſon was becauſe
the Stick was to heavy at the upper end,
and too light at the lower; and ſo the
Center of Gravity of the Rocket and
Stick was too near the Rocket: when in-
deed the Center of Gravity ſhould be in
the middle, betwixt the lower end of the
Stick and upper end of the Rocket; and
to do which the bigger end of the Stick
ought to be downward; by this means a
lighter Stick would ſerve, and if the Wind
did drive the Rocket, the Rocket would
move leſs, and yet perpendicular to the
Horizon. Nature it ſelf has taught us the
ſame; for all Birds, eſpecially Birds of
a ſwift flight, ſpread their Tails for their
Guide. Sticks of Rockets ought to be one
to

to another as the length and Diameters
of the respective Rockets; that is, as the
Diametre 1 ½ Inch is to the thickness of
its Stick, so is 4 Inches the Diameter of
a 4 Inch Rocket to the thickness of its
respective Stick. As the length of one
Rocket is to its Stick; so is the length of
any other Rocket to its Stick: and as the
weight of one Rocket is to the weight of
its Stick; so is the weight of any other
Rocket to the weight of its respective Stick.

PROPOSITION X.

To fire the Rocket.

PLace the Rocket perpendicular to the
Horizon by four Nails, make a port-
fire, about half an Inch in Diameter,
with single Paper, *viz.* 1 Sulphur, 2 Saw-
dust sifted fine, or rather Logwood
beaten and sifted fine, 4 of mealed
Powder, and 8 of Saltpetre; or make the
port-fire with Rocket Composition: fire
the port-fire, move it gently towards the
Orifice of the Rocket till it takes fire.

Obser:

Observations concerning Rockets.

(1.) IF a Rocket be driven not hard e-
nough it either consumes or breaks;
if just hard enough it rises well; if two
hard it turns a loft, and breaks not at the
just turn.

(2.) If a Rocket be bored not deep
enough it will not rise well; if just deep
enough it rises well; if too deep it often
breaks.

(3.) If a Rocket be bored with too
great a Borer it will not rise well; if with
a fit Borer it rises well; if with too small
a Borer it breaks, or rises not well.

(4.) If the Composition be too moist it
will not rise well; if too dry it rises too
fast or breaks.

(5.) If a Rocket be made, and kept in
too dry or too moist a place, it will have
the same effect as at the (4.)

(6.) The

(6.) The Velocity of a Rocket is caufed by the boring, or in the hollow Cone; the time of its flight is in the folid part above the boring, which folid part ought to be lefs in a great Rocket than in a little one. From thefe Obfervations a Youth may take any Compofition (in Reafon) and make a good Rocket.

PROPOSITION XI.

The weight of the Mallets for Rockets.

THE weight of the Mallets which Rockets are driven with, ought to be as the Cube of the Refpective Diameters of their bores, viz. If the weight of the Mallet for an Inch Rocket be twelve Ounces, the weight of the Mallet for an Inch and half Rocket ought to be two Pounds and half, and for a two Inch Rocket fix Pounds, &c.

PRO.

PROPOSITION. XII.

How Rockets are eftimated.

ROckets are eftimated either by Meafure or by Weight; if by Meafure, then by the Common Standard by Inches or by Feet; if by Weight, then they are eftimated by Caft Iron, that is, by the Gunners Rule, viz. An Inch Rocket weigheth two Ounces and a quater: an Inch and half Rocket weigheth half a Pound : a two Inch Rocket weigheth a little above a Pound : a three Inch Rocket weigheth almoft four Pounds: a four Inch Rocket weigheth nine Pounds: an eight Inch Rocket weigheth feventy two Pounds, which may be called a Rocket Royal.

C   PRO.

PROPOSITION XIII.

Of the cauſe of the Rockets riſing.
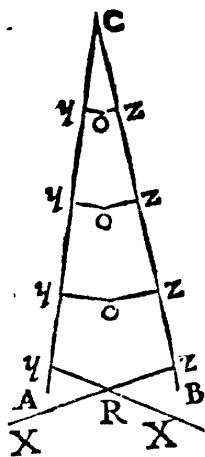
LET ACB be the hollow Cone for the the Fire, A y C Z B the Superficies of that Cone, all the Lines O Z at right Angles with B C, and all the Lines O y at Right Angle with A C; now all the Angles Z O y being towards R, whether the Angles Z O y are Obtuſe or Acute, but the more acuter the better. The Rays of fire Z O and y O iſſuing from the ſides of the Cone B C and A C, and continually agitating with greater force one upon another at O, forcing the whole Cone B C A upward from the point R; (and the wider the bore is (in Reaſon) the Rocket will riſe with the greater velocity; if the Compoſition and deepneſs of boring be ſutable.) By the Rays Z X, and

and y Z of fire, croſſing each other at the Center of the Cone R, and the point R, as it were, remains fixt; and here the ſimilitude of Guns and Rockets appears plainly, a Gun remains fixt upon the Center of Motion of the Trunnions, and projeƈts its burden forth; but a Rocket flys from its burden, leaving it at R, as it were fixt.

C 2   PART

PART II.

TO OUR

PYROBOLISTES.

A duplicate Propofition.

HAving one Rocket well proved in all its Parts, *viz.* a three Inch Rocket. Then,
To decreafe the Velocity of the Compofition of the aforefaid Rocket, to make it fit for a 4 Inch 4 ½ and 5 Inch Rocket.

And to increafe the Velocity of the aforefaid Compofition, to adapt it to a 2 Inch 1 ½ and 1 Inch Rocket, keeping the fame kind of Boring.

Secondly, From the expofed Rocket of 3 Inches, to increafe the Diameter of the Orifice of the Rockets of 4 : 4 ½ and 5

C 3   Inches

Inches Diameter; and to decreafe the Diameter of the Orifice of the Rockets of 2: 1 ½ and 1 Inch Diameter, to a-dapt them to the expofed Rocket, keeping the Compofition of the fame Velocity.

From Experimental and Mathematical Demonftration.

The Refolution of this Problem will manifeftly fhew, the invalidity of the Doctrine of Shooting by the increafe and decreafe of Powder; and that weak and narrow Scantling it pinfolds in, *too mean for this lofty Engine.* It alfo tells the Gun-Founder how to give his Guns their due Fortification; otherwife they may become ufelefs Inftruments of War. It teacheth our *Pyroboliftes* to direct their Work fo that it may rife well, and not break nor fall. It teacheth Artificers to increafe and decreafe the force or ftrength of their Materials in any poffible Proportion affigned.

> *This Propofition was publickly propofed three Months before the publication of this Book, but no Refolution given by any.*

PRO:

PROPOSITION XIV.

The Complication of Rockets in Relation to their Borers.

FRom a 2 Inch and half Rocket, we Complicate other Rockets, *viz.* a four Inch Rocket thus, we take the Cube of 4, which is 64, allo we take the Cube of 2 ½, which is 15.625, with which we divide 64, the Quotient is 4; and fo many times the lefler Rocket is contained in the greater, that is as 4 is to 1. Then I look into the Tables of Ranges for the year 1691. *June* 1, and in the fecond Column I find the requifite of Powder 1 and 4, and againft the 4 in the third Column I find the Range 3377; and in the third Column againft 1 I find the Range 652, which I multiply by 4, the Ratio of the Rockets, and it is 2608 : Now if this laft Number had been equal to 3377, the Range with the Quadruple of Powder, it would have confirmed the fhooting by the increafe and decreafe of Powder;

C 4

Powder ; but as it is fhort, it is a vifible Demonftration of the error of that Doctrine : and if the Doctrine of fhooting by the increafe and decreafe of Powder were true, there would be no need for our Pyroboliftes to give different Velocities of Compofitions to different fizes of Rockets, but one Compofition would have ferved all fizes ; which every Youth knows the Contrary.
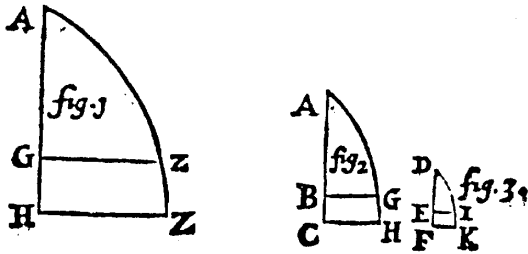
In the Parabola A H Z let A G be 2608, and A H 3377; then G Z and H Z are the Velocities of the equal and unequal Ranges. *Toricellius* 22. *Prop. de motu projec. lib fecund.*

Then as G Z the Velocity of the equal Range; is to one third of the Diameter of the four Inch Rocket 1.333 ; fo is H Z the Velocity of the unequal Range,

Range, to a larger Diameter of the 4 Inch Rocket, to keep the fame Compofition.

Or as the equal Range 2608, is to the unequal Range 3377 ; fo is the fquare of the Diameter of the Orifice of the 4 Inch Rocket, to the fquare of the Diameter of the Orifice of the Rocket inlarged, keeping the fame Compofition.

Or as the equal Range 2608, is to the unequal Range 3377 ; fo is the Area of the Orifice of the Rocket of 4 Diameter, when taking $\frac{1}{3}$ of the Diameter ; to the Area of the Orifice of the fame Rocket when enlarged, to bare the Compofition that would ferve a Rocket of two Inches and a half, taking $\frac{1}{3}$ of the Diameter of the Rocket for the Diameter of its Orifice.

Example.

2608	The equal Range	3.4'6308
3377	The unequal Range	3.528531
The fquare of 1.333, &c. the Diam. of the equal Orifice }		.249660
Take the half		.36188
The Diam. of the new Orifice 1.516 one Inch and half }		.18994

Take

Take another Example.

August 24. 1691. I look in Column 2, and find the Requisites of Powder half an Ounce, and 2 Ounces, and against those Requisites in Column 3 I find 1482 the unequal Range, and 236 the equal Range; which I multiply by 4, and it makes 944.

944 The equal Range	2.974972
1482 The unequal Range	3.170848
The Square of 1.333, &c. the equal Orifice	.249660
	.445536
The Diameter of the new Orifice 1.67	.222768

Here may be seen the concurrence of Experiments made upon another account, not then thinking to apply it to the Complication of Rockets. I made 2 Rockets of 4 Inches Diameter, and a Taper bit according to this method, and bored three Diameters, and left 2 Inches Solid, and they rose well.

An example of a Rocket of 6 Inches Diameter, keeping the same Composition. Take the Cube of 6, which is 216, divide

divide that Cube by the Cube of 4, which is 64, the Quotient is 3, that is the Composition in the Rocket of 4 Inches, is to the Composition in the Rocket of 6 Inches, is as 1 to 3 ; then I look in the Table of *Aug.* 24. and find in the second Column the Requisites of Powder half an Ounce, and an Ounce and a half; and against these Requisites in Column three 800, the unequal Range, and 236 the equal Range, which I multiply by 3, and it makes 708 : then as 4 is to 6, so is twelve half quarters of an Inch, the Diameter of the new Orifice of the four Inch Rocket, to eighteen half quarters of Inches; that is 2 Inches and 1 quarter : or as 4 is to 6, so is 1 ½, that is 3 halfs, to 4 ½ half Inches, that is 2 ¼. Then I had no such Ranges, that their Requisites of Powder were in Proportion as the Cube of 6 is to the Cube of 2 ¼; therefore was I forced to help my self by Proportion, which is the same in Substance.

708 The equal Range	2.850033
800 The unequal Range	2.903089
The Square of 2 ¼, or 18 half quarters	2.510544
The half of this Logarithm	2.563600
Half quarters of Inches 19.13 that is 2.3 is	1.281800

A

A second Example, April 21. 1692.

I look in Column 2, and find the Re-
quifites of Powder 12 Drams, and 36
Drams; and againft thefe Requifites in
the third Column I find 1176 the unequal
Range, and 303 the equal Range, which
I multiply by 3, and it makes 909.

909 The equal Range   2.958564
1176 The unequal Range   3.070407
The Square of 18 half quarters   2.510544
                             2.622387
20.47, that is 2 Inches and a
half, and $\frac{47}{100}$ } 1.311193

Here may be feen one Example
makes the Diameter a little more than
two Inches and a half, and in the other a
little lefs, therefore we make the Taper
Bores juft two Inches and a half for a 6
Inch Rocket. To work from a two Inch
and a half Rocket to an Inch, put the
unequal Range in the firft place, and the
Work is done. The Compofition thefe
4 and 6 Inch Rockets were made of, were
1 Sulphur, 1 ½ Coal, and 4 Saltpetre; but
I believe 1 Sulphur, 1 Coal, and 4 Salt-
petre would do better, there being no
great

great danger of the Rocket breaking, by
Reafon of the large Diameter of the
Bore, and Tapering to a point; and
by the fame Reafon, a leffer folid Head
is required, that is about 2 Inches in a 4
Inch, and 1 ¼ in a 6 or 8 Inch Rocket,
will fuffice.

PROPOSITION XV.

The Complication of Rockets in Rela-
tion to their Compofition, with fome
Cautions and Limitations.

TO decreafe the Velocity of the Com-
pofition of 1, 1 ½, and 4, which
ferved to a 2 ½ Inch Rocket, to make it fit
for a 4 Inch Rocket: remember the Ratio
of the Rockets are as 1 to 4. Look in the
Table of Ranges, and find the Requifites
of Powder in the fecond Column, as 1 to
4, and againft them in the third Column
the Ranges, *viz.* 3377 and 652, then
multiply the equal Range by 4, and it is
2608, (in fig. 1.) In the Parabola Z A H,
let A H be equal to 3377, and A G equal
to 2608; then H Z, and G Z will be
the

the Velocity of the Powder, which pro-
jected thoſe Ranges, and we increaſe or
decreaſe the Velocity of the Salpetre by
the Ratio of G. Z to H Z: then let A C
in fig. 2, be equal to H Z in fig. 1, and
A B in fig. 2, be equal to G Z in fig 1;
then draw the Ordinate C H and B G in
fig. 2, and by theſe two Lines, *viz.* C H
and B G we increaſe or decreaſe the Ve-
locity of the Coal. Further, let D F in
fig. 3, be equal to C H in fig. 2; and D E
in fig. 3. be equal to B G in fig. 2 : draw
the Ordinates F K and E I, and by theſe
2 Lines we increaſe or decreaſe the Ve-
locity of the Sulphur.

Then if we take the Logarithm of
(o)   (1)   (2)   (4)   (8)
3577   3.518531 1.759265 0.879632 0.439816
　　　 And is
2608   3.416308 1.708154 0.854077 0.427038

that is, the Ranges under (o), their Lo-
garithm under (1) the half of the Log.
under (2), the numbers anſwering thoſe
Logarithms are the Lines H Z and G Z
in fig. 1. The Logarithm under (4) is
the fourth part of the Logarithm under
(1): The Numbers anſwering theſe Lo-
garithms, are the Lines C H, and B G in
fig. 2.

fig. 2. Further, the Logarithm under (8)
is the eighth part of the Logarithm under
(1); the Numbers anſwering thoſe Lo-
garithms, are the Ordinates F K and E I
in the Parabola F D K.

Or you may take the difference⎫
　of the Logarithms under (1)⎬102223
viz.　　　　　　　　　　　　⎭

Half	51111
Quarter	25555
Eighth	12777

By Adding or Subtracting theſe Log.
to or from the Logarithm of the Salt-
petre, Coal, and Sulphur, you have your
deſire, *viz.* their Velocities either in-
creaſed or decreaſed : or thus, take the
difference of the Logarithm of the two
Ranges 102223, and Subtract it from the
Logarithm of the Square of the Number
of Drams, Ounces, or Pounds of Salt-
petre, or from the Logarithm of the fourth
power of the Numbers of Drams, Ounces,
or Pounds of Coal. And Laſtly, that
difference being Subtracted from the Lo-
garithms of the eighth power of the Num-
ber of the Drams, Ounces, or Pounds
of Sulphur, there will remain three Lo-
garithms, the firſt being divided by 2, the
　　　　　　　　　　　　　　　　　ſecond

fecond by 4, and the third by 8; there will remain three Logarithms, the Numbers anfwering to which, will be the Number of Drams, and Tenths of the Saltpetre, Coal, and Sulphur defired.

To Weaken the Velocity of the Compofition of 1, 1 $\frac{1}{2}$, and 4.

3377	The unequal Range	3.518531
2608	The equal Range	3.416308

The Square of 64 Drams of Saltpetre } 3.612360

Take the half 3.510137

Drams 56.9 nine Tenths of Saltpetre } 1.755068

The fourth power of twenty four Drams of Coal } 5.520844

The difference of the Logarithm of unequal, and equal Ranges Subtract } .102223

Is the Logarithm of the fourth power, which being divided by fourth } 5.418621

22 Drams $\frac{61}{100}$ of Coal 1.354655

The

The eighth power of fixteen Drams of Sulphur } 9.632960

The difference of the Logarithm Subtract } .102223

Is the Logarithm of the eighth power which being divided by 8 } 9.530737

15 Drams $\frac{45}{100}$ of Sulphur 1.191342

The Compofition will be Sulphur 15 $\frac{1}{2}$, Coal 22 $\frac{1}{2}$, and Saltpetre 57; but if you quicken the Velocity, the equal Range will be in the firft place of the Proportion.

D   PRO-

PROPOSITION XVI.

Tables of Ranges made with Mortar-pieces.

JUne 1. 1691. On *Wimbleton-Heath* at 15 *deg.* of Elevation, with a four Inch Mortar-piece, and a turned Iron Ball.

1	2	3
Experiments.	Powder.	Chain.
1	½	213
2	1	652
3	2	1640
4	4	3377

August.

August 24. 1691: At 15 *deg.* of Elevation, with a 3½ Inches Mortar-piece, and a turn'd Iron Ball.

1	2	3	4	5
	The Chamber of this Mortar-piece a Frustum of a Cone.		The Chamber of this Mortar piece a Frustum of a Sphere.	
	Powder	Chain.	Powder	Chain.
1	½	236	½	144
2	1	496	1	304
3	1½	800	1½	1258
4	2	1482	2	3394

D 2   *April*

April 21. 16)2. At 15 *deg.* of Elevati-
on, with a 3½ Inch Mortar-piece, and
a turn'd Iron Ball.

1	2	3
Experiment.	Powder.	Chain.
1	12	303
2	24	746
3	36	1176
4	48	1820
5	60	2698

Thus have I given plain and easie
Rules to the Young Pyroboliftes for the
making of small Rockets; and also for
the making of great Rockets, to them of
a greater Knowledge and Purse, even
such as was reputed impossible; for a 4
Inch Rocket was given in by our ableft
Pyroboliftes to be out of size, and there-
fore impossible to rise. Now, if that 4
Inch Rocket was thought so, what will
they say to them of 6, 8, 10 or 12 Inches
Diameter; for certainly this Rule takes in
all sizes to 500 or 1000 weight, or higher.

Necessa-

Necessary Tables for Rockets.

Inches and half Inches.	Pounds of Rockets.	Ounces	Ounces of Compos. for Rockets.	Pounds of the Mall.	Ounces
1	2	3	4	5	6
1		02	0.01		12
1½		08	0004	0002	08
2	001	02	0010	0006	00
2½	002	04	0018	0011	11
3	003	12	0032	0020	01
3½	006	00	0051	0032	04
4	009	00	0076	0048	00
4½	012	13	0108	0068	08
5	017	09	0148	0093	12
5½	023	06	0197	0126	12
6	030	06	0256	0162	00
6½	038	10	0326	0206	06
7	048	04	0407	0251	00
7½	059	05	0500	0316	06
8	072	00	0607	0384	00
8½	086	06	0728	0460	09
9	102	08	0864	0546	12
9½	120	09	1016	0643	00
10	140	10	1285	0748	04
10½	162	13	1372	0868	03
11	187	02	1578	0998	04
11½	213	14	1805	1140	10
12	423	00	2048	1296	00

The

The Use of these Necessary Tables.

IN the first Column you have the Inches and half Inches, to 12 Inches. In the second and third Columns you have the weight of Pounds and Ounces of the Rockets, when six Diameters in length. In the fourth Column you have the Ounces of Composition to fill those Rockets 4 Diameters. In the fifth and sixth Columns you have the weight of the Mallets to drive those Rockets in Pounds and Ounces.

An Example in the whole, for a three Inch Rocket. I find 3 in the first Column under Inches and half Inches; in the second and third Column, under Pounds and Ounces of Rockets, I find three Pounds and 12 Ounces the weight of the Rocket when finished, being 6 Diameters. In the fourth Column I find 32 Ounces of Composition to fill 4 Diameters. In the fifth and sixth Columns I find 20 Pounds 4 Ounces for the Mallet to drive that Rocket.

When Rockets are of a great weight, the Mallet will be too heavy to manage, therefore do thus. The Mallet of a three Inch Rocket, viz, 20 Pounds weight is
of

of a good size; and we will make an Example of a 3 Inch and 7½ Rockets, and we will take it as useful that all Rockets to 3 Inches Diameter, may be filled with eight Charges, but further not, then against 7½ in the first Column. In Column 4 I find 500 Ounces of Composition for that Rocket, which I divide by 8, and the Quotient will be 62.5. In the Parabola A H Z, let A H be the Number of Ounces 5062.5 in the Mallet for the 7½ Rocket, and A G the Number of Ounces 324 in the Mallet for a 3 Inch Rocket; then the Ordinates H Z and G Z will be the Forces of those Mallets; then as H Z is to G Z, so is 62.5 to 15.811, that is 15 Ounces and $\frac{811}{1000}$ shall be your Charge of Composition. Further, divide 62.5 by 15.811, the Quotient will be 3.$\frac{2112}{10000}$, the Number of Charges in the eight part of the Composition; then multiply 3.9529 by 8, there will be 31.$\frac{223}{1000}$ Charges in that Rocket. Lastly, give about eighteen blows to every Charge, with that Mallet for the 3 Inch Rocket, so your Work will be done, by two Men, in two hours.

324	2.510545
62.5 Squared	3.591760
	6.102305
5062.5 Sub.	3.704364
2	2.397941
15.811 is Sub.	1.198970
62.5 is from	1.795880
3.9529 Reft	0.596910
8. Log.	0.903090
31.623 Sum of 2 Logarithm	1.500000
15811 Add	1.198970
500. the Sum of Logarithm	2.698970

June 26. 1696. Then was fired a 4 and 6 Inch Rocket, Mr. *Ayres* Junior fired them both off a hand, Mr. *Dandridge*, Mr. *Rodway*, my felf, and feveral other being prefent: the 6 Inch Rocket had 3 Inches folid Head, that is about the double of what it ought to have had, the Reafon of that was to hold Fire; it moved off the Nails at about 78 *deg.* of Elevation, and the Horizontal Range was juft 15 Chains, that is 330 Yards, by which we may find the Altitude of that Parabola it moved in, and the greateft Range, and Confequently the greateft Perpendicular Altitude it could have reached.

In
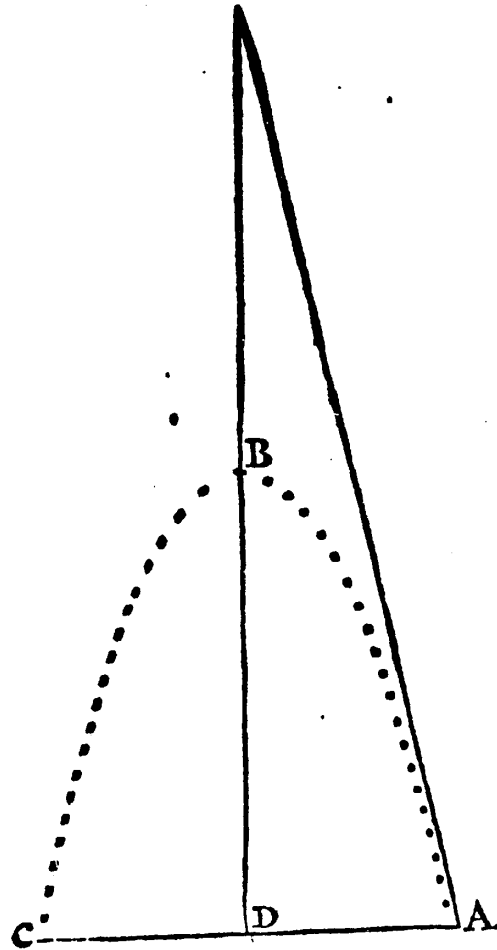
In the Parabola A B C, Let A C be equal to 330 Yards, A D equal to 165 the Angle D A E 78 degrees, then in the right Angled Triangle E D A.
      Radius

Radius	·	90	10.000000
Tangent	·	78	10.672525
A D		165	2.217484
D E		776.22	2.889989
D B		388.11	
As the Sine of the double of the Elevation		407	2.609594
Is to Radius		1000	3.000000
So is the Horizontal diſtance at 78 *deg.*		330	2.518514
To the greateſt Range in the Parabola		810.8	2.908920
Half of the greateſt Range is the Perpend. hight deſired		405.4	

So then the greateſt height of that 6 Inches Rocket in its flight was three hundred eighty and eight Yards, had it been put Perpendicular, its height would have been four hundred and five Yards.

The flight of Rockets does ſufficiently well agree with that of the Parabola at each end of the Quadrant; but towards 45 degrees it differs more.

A Rocket of an Inch and half Diameter, filled 5 Diameters, and bored two and a half, and a little more, with this Compoſition, *viz.* 8 Powder-duſt, 6 Saltpetre, 2 ½ Coal, and 1 Sulphur, and layed to 30 degrees of Elevation; Ranged the Rocket 880 Yards, that is half a Mile.

To make Rockets to Swim upon the Water, Dive into the Water, and keep above the Water.

An Example of an Inch Rocket.

MAke the Caſe 12 Diameters, which will be in this Example 12 Inches, fill it with two Compoſitions, *viz.* a Weaker and a Stronger; fill 2 Inches with the Weaker Compſition, then 1 ½ with the Strong, then 2 with the Weak, 1 ½ with the Strong. Laſtly, 2 Inches with the Weak, then there will remain 3 Inches for Corn Powder, for the Report.

The Weak Compoſition to Swim above Water; take 3 of meal Powder, 1 of Coal.

The Strong Compoſition to Dive under the Water, and leap above the Water; take 8 of mealed Powder, 1 of Saltpetre, and 1 of Coal.

To divide the Driver.

FRom the lower end of your Driver fet off 3 Inches, then 2 Inches, then 1 ½, then 2 Inches, then 1 ½. Laftly, 2 Inches; make the Rockets of a juft length, and fo you may fee the Divifions of the Driver appear above the Cafe as you fill.

The Ufe.

FIre the Rocket in your Hand with with your Port-fire, through it into a deep Water, (otherwife it will ftick in the Mud) it will Swim a little while; but when the Strong Compofition takes fire it will Dive, and when the Strong Compofition is fpent it will jump up, &c. The Weak Compofition being the laft, the Rocket for fome time will Swim upon the Water, and then give a Report. This Rocket is all Solid.

To make a Rocket Charger.

LET the length of the Charger E G, be one Diameter and half, the breadth of the Charger H Z, one Diameter and one third, the length of the Neck

Neck of the Charger that flippeth upon the Handle B C, two Diameters; the breadth of that Ferril A B, one third of the Diameter of the Rocket: betwixt eight or nine of thefe Charges will fill a Rocket 4 Diameters.
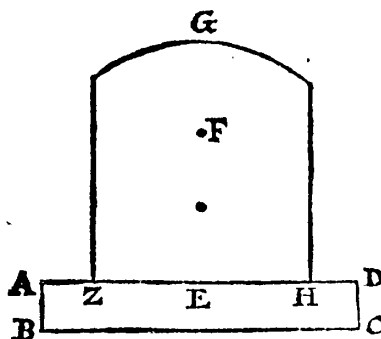
You may cut the Charger A B C D H G Z A in Paper, then it may be made in Copper, Clofe A to D, and B to C, Sodder both ends together; bring H G Z into more than half a round, and A B and C D in a round, put it then upon a Handle, then it is fit for ufe.

T●

To make good Coal for Rockets.

TAke pieces of a light dry Deal Board about 12 Inches in length, and about the thickness of 2 Fingers or lefs; put them into an Oven, put fire to the Wood; when they are burned enough take them out, and put them into an Iron, Brafs, or Eathern Pot, clofe it well with a Cover, that it takes no Air, the Fire being extinguifhed, beat it and pafs it through a fine Sieve, then it is fit for ufe. If the Wood be not well burnt, put it into the Oven again, and fo repeat your Work: fuch Coal will make a Rocket fly very lively, if not with two much Life.

Compofitions for Reports.

	A	B	C	D
ii Saltpetre	9.	4.	3.	2.
Salt of Tartar	3.	3.	2.	1.
Sulphur	1.	2.	1.	1.

Take Sulphur 1, Tartar 3, and Saltpetre 9, grind thefe well together, and dry them. A few Grains of this Powder being fired, will give as great a Clap as a Musket when it is difcharged. Dr. *French,* *pag.* 171. Take any of thefe Ingredients under

under A B C or D, mix them well together, put a little quantity of that mixture into a Fire-Pan, fet it upon the Fire, and in a little time it will give a great Report.

A further ufe of the Tables.

WHat is done in the 14 and 15 Propofitions, by taking the Cubes of the Diameter of the Bores of the Rockets, may be done by the Tables in 2 and 3, or Tab 4. Thus, look in the firft Column for the Diameters of the Rockets, *viz.* 2 and 4, and againft them, in Column 2 and 3, I find 2 Pounds and 4 Ounces, and 9 Pounds, divide the greater Number by the lefler, the Quotient will be 4, near enough, fo the Ratio of thefe two Rockets are as 4 to 1, and this is by the weight of the Rockets.

In the other Example I find 4 and 6 in the firft Column, and againft them 1 Column 4, I find 76 and 256 Ounces of Compofition for thefe two Rockets; then divide the greater by the lefler, the Quotient will be 3 and more, which is the fame thing as if you made ufe of the Cubes of their Diameters; for indeed thefe Tables are made by the Cubes of the refpective Diameters.

A

A Conclusion.

IF any one presumes to say they have Resolved the 14. Proposition before the Publication of this, they might have been so kind as to put it into Practice for the Defence of the Nation. If any say they can do it, I desire them so to do, *That I may see my desires accomplished*, viz. Great Guns and their Carriages truly fortified and neatly made, *which would be great satisfaction* ; however this may shew to the next Age what has been offered to this.

July 25.
1696.

MVSEVM
BRITAN
NICVM

F I N I S.